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P01/7700 0.00-0218442.2

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
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1. Your reference	PAAMBA195
2. Patent application number *(The Patent Office will fill in this part)*	0218442.2 — 09 AUG 2002
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	Ashe Morris Limited 6 Christchurch Crescent Radlett Hertfordshire, WD7 8AH
Patents ADP number *(if you know it)*	8442311001
If the applicant is a corporate body, give the country/state of its incorporation	
4. Title of the invention	HEAT EXCHANGES – THE BENEFITS OF USE CROSS FLOW FOR DELIVERY OF HEAT TRANSFER FLUID
5. Name of your agent *(if you have one)*	BAWDEN, Peter Charles
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	Bawden & Associates 4 The Gatehouse 2 High Street Harpenden Herts AL5 2SP
Patents ADP number *(if you know it)*	07703572002 ✓

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number or earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*	YES

a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

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Continuation sheets of this form	
Description	4
Claim*(s)*	
Abstract	
Drawing*(s)*	

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I / We request the grant of a patent on the basis of this application.

Signature Date 9 Aug 2002

12. Name and daytime telephone number of person to contact in the United Kingdom: Peter Charles BAWDEN 01582 466700

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent of the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

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e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

Heat exchangers - the benefits of use cross flow for delivery of heat transfer fluid

The size of a heat exchanger is defined in terms of its heat transfer area using the general equation shown below:

$$Q = U.A.LMTD$$

Where	Q = process heat load	(kW)
	U = overall heat transfer coefficient	($kW.m^{-2}.k^{-1}$)
	A = heat transfer area	(m^2)
	$LMTD$ = log mean thermal difference	(K)

The thermal gradient (LMTD) is determined as follows:

$$LMTD = [(tpi-tso)-(tpo-tsi)]/ln[(tpi-tso)/(tpo-tsi)]$$

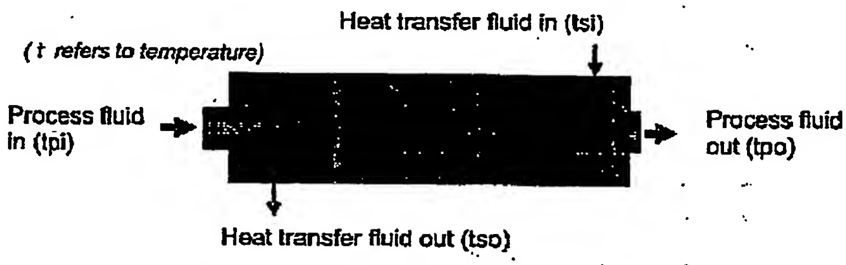

Figure 1 – Schematic of a typical heat exchanger.

The rate of heat flow into or out of the process fluid is determined by the thermal gradient (LMTD), the heat transfer area (A) and the heat transfer coefficient (U). The heat transfer coefficient is determined by the ease with which heat can flow across the heat transfer boundary. An idealised heat exchanger boundary is shown below.

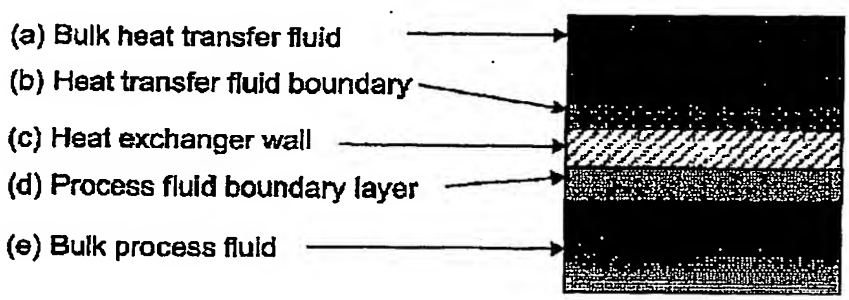

Figure 2. Idealised section through the heat transfer boundary

Classical heat transfer theory assumes that heat flows by conduction across three layers as shown by b, c, and d in figure 2. The middle layer c, is the heat exchanger wall. The wall has constant thickness and a substantially constant thermal conductivity. Either side of the heat exchanger wall are stagnant layers of liquid (boundary layers). The resistance to flow across these layers is dependant on the thermal conductivity of the liquid and the thickness of the boundary layer. The thickness of the boundary layer can be reduced by increasing the turbulence and shear of the heat transfer fluid. This is generally achieved by increasing the fluid velocity.

Improving heat transfer conditions for the heat transfer fluid.

To illustrate how the heat transfer capacity can be improved, a conventional batch reactor will be used as the example.

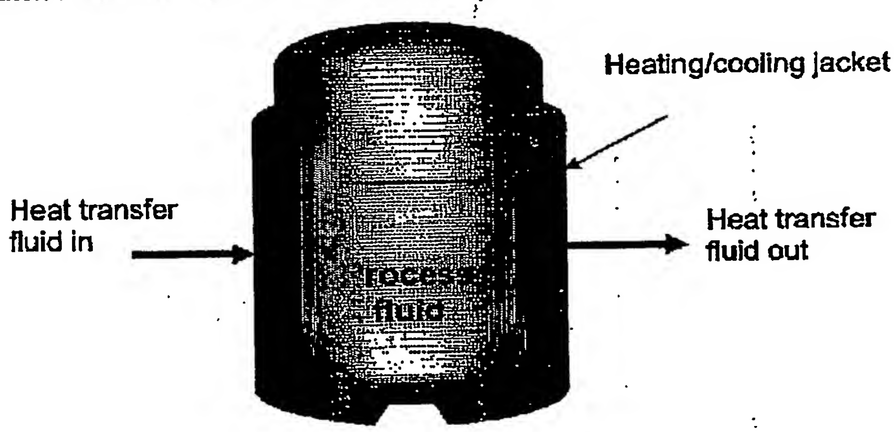

Figure 3. Schematic of a batch reactor (process connections not shown)

The vessel shown in figure 3 is a conventional batch reactor, which is two thirds full of process liquid. A jacket surrounds the vessel to add or remove heat from the process. In figure 3, the cooling (or heating fluid) supply is shown as an arrow.

In practice, there would be several problems with the design shown above. Firstly, the fluid is shown entering at one point. This would result in poor distribution of the heat transfer fluid (especially on large vessels). Secondly, the jacket represents a large cavity and fluid would pass through it at low velocity and with minimal turbulence.

To overcome these problems, manufacturers use multiple inlet ports. They also use techniques to improve turbulence within the jacket by one of two common methods.

(a) Baffles are fitted inside the vessel to direct flow through the jacket. This improves distribution of the fluid and increases turbulence.

(b) The other method is to inject the cooling fluid through a tangential nozzle. This creates a rotating ring of cooling fluid within the jacket which increases turbulence.

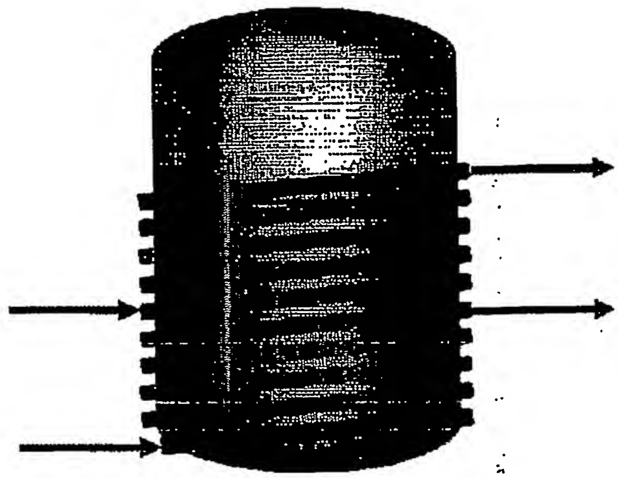

Figure 4. Half coil jacket with two inlet ports.

An alternative design, which gives very good turbulence and good fluid distribution, is the half coil jacket. The example shown in figure 4 has two inlet ports. This design is better than the jacketed design by virtue of inherently better fluid distribution and high turbulence of the heat transfer fluid.

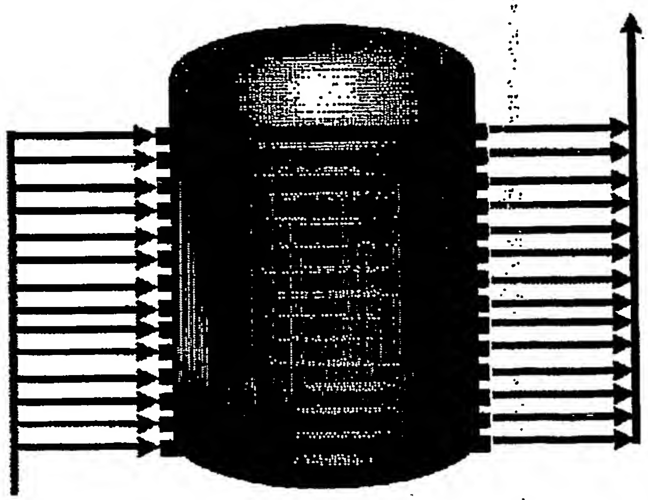

Figure 5. Cross flow jacket

A further improvement to the jacket design can be achieved using a cross flow configuration as shown in figure 5. This is similar to the half coil arrangement except that a large number of inlet and outlet points are fitted. For a given pressure drop, a much higher flow velocity of heat transfer fluid can be achieved. The distribution of heat transfer fluid is more even and in some cases, better LTMDs can be enjoyed. The advantage with this design is that better heat transfer coefficients can be achieved and heat transfer fluid can be replaced more quickly (which is desirable for good temperature control).

The example shown in figure 5 is schematic only. In practice, the inlet and outlet pipes would usually be close together to ensure that the fluid travelled all around the full surface of the vessel wall. There are numerous arrangements that can be used. Some examples of which are shown below.

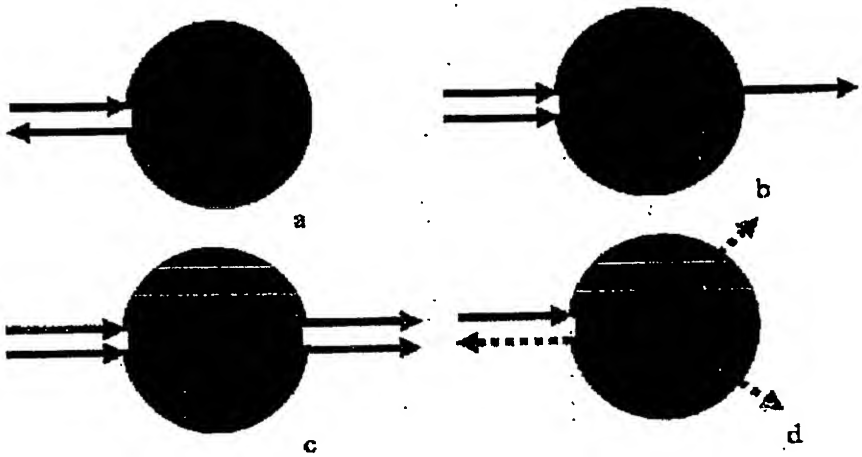

Figure 6. Schematic plan view of a cross flow jacket showing examples of different flow routes.

In addition to the examples shown here it would also be possible to have more than one winding of the coil between inlet and out. It should also be noted that the flow path might be less than a full turn as shown in figure 6c.

Note – the examples given here use a conventional batch reactor. The principle of cross flow can readily be applied to a variety of other types of heat exchanger.